Journal of Pharmaceutical and Biological Research
ISSN: 2347-8330 | https://doi.org/10.30904/j.jpbr.2026.4920

Plant-Based Multifunctional Nutraceuticals as Preventive Interventions for Modern Lifestyle Disorders

T. Usha Kiran Reddy*[1], K. Gunasree[2], G.V.N. Sreevalli[2], S. K. Umar Farooq[2], T. Uma Maheswari[2]

[1]*Faculty, S V University College of Pharmaceutical Sciences, S V University, Tirupati – 517502, AP, India*
[2]*Students, S V University College of Pharmaceutical Sciences, S V University, Tirupati – 517502, AP, India*

***Corresponding E-mail:** usha.t2789@gmail.com*

Received: 17-12-2025 | Revised: 12-01-2026 | Accepted: 22-02- 2026 | Published: 10-03- 2026

ABSTRACT
In recent years, herbal formulations and nutraceuticals have gained wide acceptance due to their minimal adverse effects. Medicinal plants are known for their immune-enhancing properties, and nutrition during early childhood plays a crucial role in a child's overall growth and development. Despite consuming a balanced diet, children often suffer from deficiency-related disorders. Owing to their close interaction with gut microbiota, nutraceuticals currently serve as an effective alternative for the prevention and management of dysfunctions associated with oxidative stress. Chronic non-communicable diseases such as cancer, diabetes, hormonal disorders including PCOS, cardiovascular diseases, neurodegenerative conditions, and autoimmune disorders are increasing worldwide, creating significant health and economic burdens. The primary objective of this study was to develop a multifunctional nutraceutical formulation using ingredients derived from various sources such as medicinal herbs, seeds, spices, and green leafy vegetables. The pharmacological efficacy of the formulation was evaluated through its mechanisms of action, including biotransformation processes and identification of relevant biomarkers. Since inflammation is one of the major contributing factors to disease progression, its reduction is essential, as it promotes the generation of free radicals and gut dysbiosis.
Keywords: Nutraceutical, non-communicable diseases, biomarkers, free radicals, dybiosis

Introduction

Non-communicable diseases (NCDs), also known as chronic diseases, are long-lasting conditions that usually develop slowly and persist throughout life. They include a wide range of disorders such as arthritis and other musculoskeletal diseases, diabetes mellitus, cancer, chronic respiratory illnesses, and cardiovascular conditions like hypertension and coronary artery disease. The World Health Organization reports that NCDs account for nearly 74% of all global deaths each year, with cardiovascular diseases alone responsible for more than 17.9 million deaths [1]. These diseases arise from a complex interplay of behavioural, physiological, environmental, and genetic factors, and their incidence continues to rise due to population aging, unhealthy diets, psychological stress, and sedentary lifestyles [2].

Although modern pharmaceutical treatments have significantly improved survival rates and quality of life, they also have notable limitations. Many conventional drugs focus primarily on managing symptoms rather than addressing the underlying causes of chronic diseases. Long-term use of such medications is often associated with adverse effects, drug resistance, and poor patient adherence. For example, prolonged use of nonsteroidal anti-inflammatory drugs (NSAIDs) in arthritis patients can lead to renal damage, gastrointestinal ulcers, and increased cardiovascular risk. Likewise, while chemotherapeutic agents are effective in cancer treatment, they frequently cause severe side effects that substantially reduce patients' quality of life [3]. Because of these limitations, natural products and nutraceuticals are increasingly recognized worldwide as viable alternatives or adjuncts to conventional medical therapies. Nutraceuticals are food-based products that deliver health-promoting and therapeutic benefits beyond basic nutritional value, as they contain a wide array of bioactive constituents such as vitamins, minerals, flavonoids, polyphenols, omega-3 fatty acids, and plant-derived extracts. These bioactive compounds have been reported to possess multiple beneficial properties, including antioxidant, anti-inflammatory, cardioprotective, anticancer effects [4].

Overview of Nutraceuticals and natural products:

Now a days, the use of natural products and nutraceuticals has emerged as an effective approach for the management of chronic diseases and the maintenance of overall health. Nutraceuticals are bioactive compounds derived from diverse natural sources, including plants, microorganisms, and marine organisms. Among these, plant-based nutraceuticals are the most extensively studied and widely utilized, encompassing compounds such as terpenoids, polyphenols, flavonoids, and alkaloids. These phytochemicals exhibit potent anti-inflammatory, antioxidant, and cardioprotective properties and are abundantly present in fruits, vegetables, herbs, spices, and whole grains. As reported by Shahidi et al., such compounds have been associated with anticancer effects, enhanced cognitive function, and improved cardiovascular health.

A polyherbal formulation is composed of two or more medicinal herbs containing diverse phytochemical constituents with similar or complementary therapeutic properties. When combined, these herbs act synergistically to produce beneficial effects in the management of human nutrition and health. The broad therapeutic potential of polyherbal formulations particularly their ability to remain effective at relatively high doses while causing minimal adverse effects has contributed to their widespread acceptance.

Nutraceuticals are recognized for their role in promoting health as well as in the prevention and management of diseases. They are especially beneficial for individuals who are undernourished or malnourished, as they provide concentrated sources of essential nutrients. Nutraceuticals function as nutrient-dense supplements that support bodily structure and function, enhance overall well-being, and help reduce disease risk.

What are Nutraceuticals:

Definition: A Nutraceutical can be explained as, a food or a part of food that provides medical or health benefits, including the prevention and/or treatment of disease. The term "nutraceutical" was coined from "nutrition" and "pharmaceutical" in 1989 by Stephen DeFelice, MD, founder and chairman of the Foundation for Innovation in Medicine (FIM), Cranford, NJ.

Classification of nutraceuticals

Nutraceuticals have been classified based on their application into traditional, nontraditional, fortified, recombinant, phytochemical, herbal, functional foods, dietary supplements, probiotics and prebiotics. Nutraceuticals with their different classes have a variety of applications and uses depending on their nature. The classification of nutraceuticals is shown in Table 1 [5].

Multifunctional Nutraceuticals:

Multifunctional nutraceuticals are food-derived, bio-active compounds or products that provide health benefits beyond basic nutrition, which are designed to prevent or treat diseases by targeting multiple biological pathways simultaneously. These compounds, which often include nutrients (vitamins, minerals), herbals, and dietary supplements, are known for having antioxidant, anti-inflammatory, and cardioprotective properties.

Forms: They are often found in concentrated, non-food forms like capsules, tablets, powders or in fortified foods.

Role of nutraceuticals on human health:

The role of nutraceuticals is to provide health benefits by helping to prevent or treat certain conditions. These nutraceutical products are used to improve general health, prevent disease and support the treatment of existing conditions. For example, some nutraceuticals may help lower cholesterol levels or regulate blood sugar levels, while others may help prevent cardiovascular disease and cancer. Nutraceuticals can also be used to support the immune system, reduce inflammation, or improve physical /mental performance, thus also contributing to longetivity. There are numerous scientific studies that have examined the effects of nutraceuticals, on cardiovascular disease, with some showing that certain nutraceuticals may be effective in preventing or treating cardiovascular disease.

Key roles and benefits:

Antioxidant action: Neutralize free radicals, protecting cells from damage (e.g., flavonoids, polyphenols).

Cardiovascular health: Omega-3s reduce cholesterol, plant sterols lower heart disease risk.

Gut health: Probiotics and prebiotics regulate microbiota, aid digestion, and boost immunity.

Disease prevention: Help manage risks of obesity, diabetes, cancer, and inflammatory conditions.

Neurological support:

May help with brain function and conditions like migraines, potentially reducing neuroinflammation

Role of nutraceuticals in specific chronic diseases

1. Antioxidant action: (Neutralize free radicles, protecting cells from damage (e.g.: flavonoids, polyphenols). Antioxidants neutralize harmful free radicals and reactive oxygen species (ROS) to prevent cellular damage. They work by converting ROS into less reactive forms, interrupting oxidative chain reactions or lowering local oxygen levels [6]. Primary antioxidants directly scavenge free radicals, while secondary antioxidants block ROS formation through other pathways [7]. They are vitamin C and E, carotenoids, polyphenols and flavonoids. These antioxidants aids in relieving oxidative stress by stimulating body defence mechanism which is linked to aging, cancer, heart disease, and diabetes [8]. Supplements are confirmed less effective compared to dietary intake from whole foods. Pulses including mung beans, lentils, chickpeas, and broad beans contains polyphenols, flavonoids, tannins. Walnuts are ranked high in antioxidant capacity, providing flavonoids and other protective phytochemicals. When it comes to leafy vegetables spinach is considered as one of them.

2. Cardiovascular diseases (CVD)

The top cause of death worldwide is still cardiovascular diseases, which include hypertension, atherosclerosis, myocardial infarction, and stroke [9]. The pathophysiology of CVD is greatly influenced by lifestyle variables such chronic inflammation, poor nutrition, and inactivity [10]. By focusing on important risk factors like dyslipidemia, hypertension, endothelial dysfunction, nutraceuticals present intriguing alternatives to traditional treatments [11]. The cardioprotective benefits of omega-3 fatty acids, especially eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA), which are mostly found in fish oils, are well established. They assist, in lowering blood pressure, improving vascular function, inhibiting platelet aggregation, and lowering plasma triglyceride levels. By lowering oxidative stress in vascular tissues and raising nitric oxide (NO) bioavailability, they enhance endothelial function [12]. Diets high in flavonoids have been linked to improve lipid profiles and decreased blood pressure, especially through improvements in HDL cholesterol and decreases in LDL cholesterol. They also alter lipid metabolism-related enzyme systems like lipoprotein lipase and HMG-CoA reductase. Naturally found in nuts, seeds, vegetable oils, plant sterols and stanols structurally resemble cholesterol and competitively prevent the intestinal absorption of it [13].

3. Cancer

Cancer is characterized by uncontrolled cell division, resistance to apoptosis, increased angiogenesis, and the ability of cancer cells to invade and metastasize. It continues to be one of the leading causes of morbidity and mortality worldwide [14]. Although conventional treatments such as chemotherapy and radiotherapy are widely used, their application is often limited by severe side effects and the development of resistance [15].

As a result, nutraceuticals obtained from dietary sources such as seeds, spices, herbs, and pulses are gaining importance as complementary approaches in cancer prevention and therapy due their safety, low toxicity, and multi-targeted actions. Spices and herbs are rich sources of bioactive compounds with proven anticancer properties. Resveratrol, a polyphenol found in peanuts, soy etc, demonstrates strong anticancer activity by targeting multiple molecular pathways. Overall, nutraceuticals derived from seeds, spices, herbs, and pulses act synergistically to suppress tumor growth by including apoptosis, inhibiting angiogenesis, regulating cell cycle progression, and reducing oxidative stress. Their inclusion in the daily diet, along with conventional therapies, may enhance treatment efficacy, lower cancer risk ad reduce recurrence.

4. Diabetes

Diabetes mellitus, particularly type 2 (T2DM), is a chronic metabolic disease defined by high blood sugar (hyperglycemia), insulin resistance, and decreased insulin secretion. While conventional drugs often focus on managing symptoms rather than reversing the disease, nutraceuticals are being explored ass natural, low toxicity adjuncts or alternative for managing blood sugar [16] [17].

Type 1 diabetes:

An autoimmune disorder destroying pancreatic beta cells, leading to absolute insulin deficiency; often starts in youth.

Type 2 diabetes: The most common (90-95% of cases), involving insulin resistance and eventual beta-cell dysfunction; linked to obesity, inactivity, and genetics.

Management Basics:

Diet (including millets), exercise, weight control, and medications like insulin or metformin are key; early intervention prevents complications like heart disease or neuropathy. nutraceuticals that can be incorporated into diabetic diet are flax seeds, pumpkin seeds, muskmelon seeds, and sunflower seeds. Pulses include red gram, green gram, urad dal, rajma and green mung beans. Spices include cumin seeds, and fenugreek seeds. Leaves include moringa leaves, coriander leaves, methi leaves, guava leaves, thippatheega leaves and greens include spinach etc.

5. Gut health

Gut health is a central component of health promotion and is primarily managed through specific classes of nutraceuticals, including probiotics, prebiotics, and dietary fibers.

Key Components of Gut Health

Probiotics: These are beneficial live microbes, most commonly strains of Lactobacillus and Bifidobacterium, which are often found in fermented foods like yogurt and kimchi, they help regulate the gut microbiota, enhance immunity, and reduce gastrointestinal inflammation.

Prebiotics: These are indigestive substrates such as insulin, fructo-oligosaccharides (FOS), Galacto-oligosaccharides (GOS) that selectively promote the growth and activity of beneficial bacteria in the gut

Dietary fibers: Plant-based carbohydrates like psyllium and beta-glucan promote digestion help regulate promote blood sugar, and support general metabolic health.

Biological Mechanisms and benefits

Nutraceuticals improve gut health through several sophisticated biological pathways:

Microbial balance:

Bioactive substances like polyphenols (e.g.,catechins) and prebiotics encourage the growth of "good" bacteria while inhibiting pathogenic species

Intestinal Barrier Integrity: Probiotics strengthens the intestinal barrier and lower the systemic endotoxin burden, which helps reduce systemic inflammation.

Immune modulation:

By altering the gut microbiota, probiotics can induce the production of antiinflammatory markers like IL-10, which is particularly beneficial in managing conditions like Inflammatory Bowel Disease (IBD).

6. Poly Cystic Ovarian Syndrome (PCOS)

Pathophysiology of PCOS involves a complex interplay of genetics, environment, and lifestyle, leading to hormonal imbalances (especially high androgens and insulin resistance), disrupted hypothalamic-pituitary-ovarian axis (high LH/FSH ratio) and ovarian dysfunction (anovulation, polycystic ovaries). Key drivers are insulin resistance, causing excess insulin to stimulate ovarian androgen production, and abnormal GnRH signalling, leading to increased LH and decreased FSH, ultimately resulting in hyperandrogenism, irregular periods, and infertility, often worsened by obesity and inflammation [18]. Key pathophysiological mechanisms are like Hormonal imbalance, insulin resistance & Metabolic Dysfunction, Ovarian Dysfunction, Genetic and Environmental factors. Nutraceutical management for PCOS Including fenugreek seeds, cinnamon, turmeric, spearmint leaves, and green leafy vegetables to support insulin control and hormone balance in PCOS management. These align with traditional Indian remedies like fenugreek, cinnamon, etc.

7. Obesity

Obesity is a complex, chronic disease characterized by excessive body fat accumulation that presents a significant risk to health. It is widely recognized by the World Health Organization (WHO) and major medical societies as a global public health crisis, affecting more than 1 billion people worldwide as of 2026.

Classification and diagnosis

For adults, obesity is primarily screened using the Body Mass Index (BMI), calculated as weight in kilograms divided by height in meters squared (kg/m^2).

Overweight

Overweight: BMI of 25.0 to 29.9
Obesity (class I): BMI of 30.0 to 34.9
Obesity (class II): BMI of 35.0 to 39.9
Obesity (class III): BMI of 40.0 or higher

Common Health Risks include cardiovascular diseases; type 2 diabetes, cancer, musculoskeletal disorders and respiratory issues. Causes and influencing factors are environment, genetics, psychological factors, medications, while the fundamental cause is an energy imbalance between calories consumed and expanded, obesity is often multifactorial.

Management and Treatment

Lifestyle changes: A balanced, calorie-controlled diet and 150 – 300 minutes of moderate activity per week.

Nutraceuticals that can be incorporated into our diet in order to reduce our weight and follow a balance diet Seeds like flax, sunflower, walnuts etc. Spices include cumin seeds, coriander seeds, fennel seeds, ajwain seeds, and fenugreek seeds, while

when it comes to greens methi leaves, mint leaves, amaranth contribute to weight reduction.

Edible/nutritional seeds and nuts

Seeds and nuts are sources of proteins, fats, minerals, vitamins and fibres. Seeds are botanically mature ovules and rich proteins, healthy fats, fibres and minerals such as magnesium, potassium, calcium, iron and zinc and contain vitamins such as B1, B2, B3 and vitamin E. Oily seeds are enriched with antioxidants which prevent fats and rancidity [19].

Fig.1 Edible and nutritional seeds and nuts

Table.1 Pharmacognostical Profile of Common Edible Seeds

S. No.	Name	Botanical name Family	Chemical constituents	Medicinal uses
1.	Flax seeds	*Linaceae*	Fatty acids (87.8-89.8%), proteins, palmitic acid, polysaccharides, phenolic compounds, carotenoids, amino acids etc.,	Antioxidant, hepatoprotective properties, lowering cholesterol, prevent cancer, gut health, skin improvement, lower blood glucose levels [20]
2.	Pumpkin seeds	*Cucurbita pepo L.* Cucurbitaceae	Proteins, fibre, carbohydrates, monounsaturated fats, tocopherol, delta-7-sterols, carotenoids etc.,	CVD preventive, anticancer, anti-diabetic, antiinflammatory, antioxidative, liver friendly, neuroprotective properties,[21]
3.	Muskmelon seeds	*Cucumis melo L.* Cucurbitaceae (Gourd family)	Proteins, crude fibre, carbohydrates, amino acids, fatty acids, minerals, oils	Antioxidant, support brain function, anti-cancer, antiinflammatory, anti-ulcer, anti-diabetic, antihypothyroidism [22]
4.	Sunflower seeds	*Helianthus annuus* Asteraceae	Rich in calories, fibre, unsaturated and monosaturated fats, vitamins	Supports immunity, cardioprotective effects, diabetes friendly, boosts brain function, weight management, boosts energy, good skin, antiinflammatory
5.	Cucumber seeds	*Cucumis sativus* Cucurbitaceae	Phytosterols, fatty acids, proteins, carbohydrates, fibre, minerals, and numerous phytochemicals like phenolic acids (flavonoids, tannins), cucurbitacins, saponins, and terpenoids.	Improve digestive health, hydration, heart health, regulate blood sugar levels, supports skin health, antioxidants, bone health [23]
6.	Sesame seeds	*Sesamum indicum L.* Pedaliaceae	Saponins, lignans, tocopherols, phytosterols, phospholipids, flavonoids, tannins, phenolic acids, chlorogenic acids, alkaloids	Cardioprotective, antihypercholesterolemic, hepatoprotective, neuroprotective, antiinflammatory, anti-cancer, anti-diabetic [24]
7.	Watermelon seeds	*Citrullus lanatus* Cucurbitaceae	Fats (20-50%), fibre, proteins (18-35%) minerals like magnesium, potassium, iron, zinc, phenols, tannins, vitamins	Strengthen and prevent hair breakage, skin health, support metabolism, blood sugar, heart health, immunity, improve digestion, and nervous system function
8.	Walnuts	*Juglans regia* Juglandaceae	Polyunsaturated fatty acids, proteins (14-21%), dietary fibre, polyphenols, minerals, phytosterols, gamma-tocopherol, triterpenes	Improves heart health, cholesterol levels, reduced blood pressure, brain and gut health, weight management, antiinflammation, anti-aging [25]
9.	Peanuts	*Arachis hypogaea* Fabaceae	Monsaturated and polysaturated fats, bioactive compounds like resveratrol, phytosterols, and phenolic acids, vitamins E and B, and minerals	Heart health, lowering bad cholesterol, aid in blood sugar control, weight management, antioxidant, immune boosting

Pulses:

Pulses are the edible dry seeds of leguminous plants, harvested solely as grains from pods. Pulses include crops like lentils, chickpeas, dry beans, and dry peas, grown annually and yielding 1-12 seeds per pod. They differ from fresh legumes, which are harvested green. Pulses provide 21-25% protein, higher than cereals, along with fibre, vitamins (folate), and minerals (iron, zinc, calcium). They support heart health by lowering LDL cholesterol and aid digestion despite oligosaccharides that may cause gas.

Fig.2: Common Pulses of Dietary Importance

Table:2 Phytochemical Profile and Medicinal Uses of Common Pulses

S.no	Pulse	Botanical name	Family	Chemical constituents	Medicinal uses
1.	Red gram	*Cajanus cajan*	Fabaceae	Proteins (2022%), lysine, phenolic compounds, flavonoids, stilbenes, tannins	Balances Vata/Pitta doshas, antiinflammatory, diabetes, wound healing, coughs [26]
2.	Green gram	*Vigna radiata*	Fabaceae	Flavonoids, phenolic acids (gallic, vanillic), proteins	Balances doshas, relieves Pitta/blood diseases, enhances breast milk, migraine relief [27]
3.	Urad dal	*Vigna mungo*	Fabaceae	Proteins, fibre, iron, magnesium, potassium, flavonoids, phenolics	Improves digestion, constipation, sexual dysfunction, diabetes, liver/kidney protection [28]
4.	Brown chick peas	*Cicer arietinum*	Fabaceae	Carbohydrates, proteins, amino acids, fixed oils, phytosterols, alkaloids, phenolics, tannins, flavonoids	Abdominal issues, liver enlargement, ulcers, inflammation, high cholesterol [29]
5.	Black eyed peas	*Vigna unguiculata*	Fabaceae	Phenolic acids, flavonoids, proteins, vitamins (B6, folate), minerals (iron, copper)	Diuretic, urinary tract infections, kidney problems, skin ailments, antioxidants [30]
6.	Horse gram	*Macrotyloma uniflorum*	Fabaceae	Proteins, phytic acid, phenolic acids, fibre, flavonoids, tannins	Kidney stones, urinary diseases, piles, cold, fever, antiinflammatory, diabetes
7.	Rajma	*Phaseolus vulgaris*	Fabaceae	Proteins, carbs, fibre, iron, magnesium, potassium, folate	Manages blood sugar, cholesterol, blood pressure, arthritis, skin health [31]
8.	Indian bean	Lablab purpureus	Fabaceae	Proteins, carbs, fiber, minerals	Digestive aid, anti-inflammatory, general nutrition (traditional uses vary) [32]

Spices: Spices are aromatic plant parts like seeds, fruits, roots, bark, or buds used mainly for flavouring, colouring, or preserving food. Common types include black pepper and cumin (seeds), cinnamon and cassia (bark), cloves (flower buds), ginger and turmeric (rhizomes), and saffron (stigmas). They enhance taste in small amounts, offer antioxidants and anti-inflammatory benefits, aid digestion, and have uses in medicine, perfumes, and rituals.

Table: 3 Spices Overview

S.No.	Spice	Botanical name	Family	Chemical constituents	Medicinal uses
1.	Cumin seeds	*Cuminum cyminum*	Apiaceae	Cuminaldehyde, thymol, flavonoids, terpenes, volatile oils	Digestion aid, antiinflammatory, antioxidant, blood sugar control [33]
2.	Coriander seeds	*Coriandrum sativum*	Apiaceae	Linalool, coriandrol, phenolic acids, alkaloids	Balances doshas, digestive disorders, cholesterol reduction, skin health [34]
3.	Black pepper	*Piper nigrum*	Piperaceae	Piperine, alkaloids, essential oils, flavonoids	Improves digestion, respiratory issues, pain relief, nutrient absorption
4.	Fennel	*Foeniculum vulgare*	Apiaceae	Anethole, fenchone,	Digestive aid, menstrual cramps, lactation support, eye health [35]
5.	Ajwain	*Trachyspermum ammi*	Apiaceae	Thymol, carvacrol, pcymene, fiber	Gas relief, indigestion, asthma, arthritis [36]
6.	Fenugreek	*Trigonella foenum-graecum*	Fabaceae	Soluble fiber, saponins, alkaloids, flavonoids	Blood sugar control, milk production, cholesterol lowering, antiinflammatory [37]

Fig.3 Commonly Used Indian Spices

Fig.4 Medicinal Leaves

Fig.5 Nutritious Green Leafy Vegetable

Medicinal leaves used as nutraceuticals are plant derived products containing bioactive compounds (like polyphenols, flavonoids) that provide health benefits beyond basic nutrition, acting as preventive agents against chronic diseases. Key examples include tulasi, moringa, neem, mint, curry leaves, which offer antioxidant, anti-inflammatory, and immune-boosting properties. These plants help manage lifestyle diseases, such as diabetes and hypertension, while strengthening the immune system without the side effects often associated with synthetic drugs. They are commonly consumed as teas, extracts, capsules, powders, or directly in functional foods. Active components present in the leaves are bioactive metabolites including saponins, tannins, and flavonoids.

Table: 4 Medicinal Leaves with Their Botanical Details and Uses

S. No.	Name	Botanical name	Family	Chemical constituents	Medicinal uses
1.	Flax seeds leaves	*Linum usitatissimum L.*	Linaceae	α-linolenic acid (ALA), lignans (SDG), fiber, phenols	Antioxidant, antiinflammatory, cardiovascular health
2.	Betel leaves	*Piper betel Linn.*	piperaceae	Polyphenols, essential oils, flavonoids, carbohydrates, ffibres, vitamin A	Antimicrobial agents, treat infections, digestive issues, antioxidant, anti-inflammatory [38]

Green leafy vegetables: Green leafy vegetables (GLVs) act as potent nutraceuticals by providing essential vitamins, (A, C, E, B), minerals (iron, calcium, potassium, magnesium), and phytochemicals (polyphenols, carotenoids) that reduce chronic disease risks. Examples like spinach, amaranth, moringa, and mustard greens, which offer antioxidants, anti-inflammatory, and cardioprotective benefits. These nutrient dense, low-calorie foods are crucial for enhancing immune function, improving gut health, and reducing the risk of cancer and cardiovascular diseases

.

Table: 5 Botanical Profile and Uses of Green Leafy Vegetable

S.no	Name	Botanical name	Family	Chemical constituents	Uses
1.	Spinach	*Spinacia oleracea*	Amaranthaceae	Carotenoids (lutein, βcarotene, zeaxanthin), pcoumaric acid, ascorbic acid, flavonoids, vitamins, minerals, iron	Treats diabetes, urinary calculi, asthma, liver inflammation, constipation; antioxidant and energy booster [50]
2.	Methi (Fenugreek leaves)	*Trigonella foenumgraecum*	Fabaceae	Alkaloids (trigocumarin, trigonelline), saponins, tannins, phenols, mucilage, proteins, vitamins, minerals (iron, potassium)	Anti-diabetic, antiinflammatory, digestive aid, immunity booster [43]
3.	Thotakura (Amaranth greens)	*Amaranthus viridis*	Amaranthaceae	Vitamins (A, C, K, B6), folate, minerals (iron, calcium, magnesium), phenolics, flavonoids, tannins	Treats inflammation, diarrhea, high cholesterol, anemia; diuretic, anti-inflammatory
4.	Bachalaku (Malabar spinach)	*Basella alba*	Basellaceae	Betacyanins, carotenoids, bioflavonoids, βsitosterol, lupeol, mucilaginous polysaccharides, vitamins (C, A), iron, calcium	Laxative, antiinflammatory, antioxidant, treats cough, ulcers, anaemia [51]
6.	Gongura (Sorrel leaves)	*Hibiscus sabdariffa*	Malvaceae	Flavonoids, anthocyanins, polysaccharides, phenolic compounds (chlorogenic acid), vitamins (A, C), minerals (iron, calcium)	Antioxidant, antihypertensive, antimicrobial, rich in vitamins and minerals [52]
7.	Ponaganti aku (Ponnaganni greens)	*Alternanthera sessilis*	Amaranthaceae	Beta-carotene, iron, fiber, calcium, vitamins (C, A), various phytochemicals	Wound healing, antimicrobial, antiinflammatory, hematinic, antioxidant [53]
8.	Chukka kura (Indian sorrel)	*Rumex vesicarius*	Polygonaceae	Anthraquinone glucoside, rumicin, lapathin, amino acids, vitamins, cystine, glutamic acid	Treats constipation, liver diseases, piles, vomiting, snake bites [54]

Discussion

Multifunctional nutraceutical formulations combining spices, leaves, seeds, leafy vegetables, and pulses offer promising avenues for addressing chronic conditions like CVD, obesity, PCOS, neurological diseases, and immune dysfunction. These plant-based ingredients provide synergistic bioactive compounds such as polyphenols, fiber, omega-3s, and antioxidants that target multiple pathways including inflammation, oxidative stress, and metabolic dysregulation. For instance, flaxseeds, pumpkin seeds, and other seeds that we

have added to our formulation exhibit anti-inflammatory and lipid lowering effects, reducing atherosclerosis risk in CVD while improving insulin sensitivity in PCOS and obesity [2]. Seeds like fenugreek and flaxseeds contribute soluble fiber (galactomannan) and lignans, aiding weight management by enhancing satiety, modulating gut microbiota, and lowering LDL cholesterol. Leafy vegetables such as spinach and moringa leaves supply nitrates, vitamins, and glucosinolates that support endothelial function, neuroprotection against Alzheimer's via BDNF upregulation, and immune modulation through enhanced T-cell activity. Pulses including lentils and chickpeas deliver isoflavones and resistant starch, promoting glycemic control for PCOS, reducing neuroinflammation in Parkinson's, and bolstering immunity via prebiotic effects [55]. Formulations including spice and pulse blends or combined seeds, leaf extracts improve bioavailability, as seen in multi-layer nutraceuticals with enhanced GABA and omega-3 levels for anxiolytic and cardioprotective benefits. Challenges like stability and dosage optimization persist, but clinical evidence supports their role in holistic prevention, with reduced side effects compared to synthetics. Future research should focus on standardized, synbiotic formulations for personalized therapy [56].

Conclusion

In focus on pulses, spices, leafy vegetables individual blends and snack bar constituting seeds and nuts deliver a potent, combined arsenal for health promotion, drawing from natural sources to foster overall well-being. These formulations are rich in fibre, antioxidants, polyphenols, and key micronutrients, these formulations tackle oxidative damage, bolster heart and metabolic functions, and lower risks for diabetes, polycystic ovarian syndrome and neurological decline and also offer antioxidant, anti-inflammatory, lipolytic properties. Blending them into routine meals, snacks, or supplements provides practical, science-supported nutrition, opening doors to creative functional foods and tailored strategies for contemporary preventive care.

References

[1] World Health Organization. *Noncommunicable diseases and mental health in small island developing states*. Geneva: World Health Organization; 2023 Jun 8.

[2] Fatima G, Khan S, Shukla V, Awaida W, Li D, Gushchina YS. Nutraceutical formulations and natural compounds for the management of chronic diseases. *Front Nutr*. 2025;12:1682590.

[3] O'Reilly M, Mellotte G, Ryan B, O'Connor A. Gastrointestinal side effects of cancer treatments. *Ther Adv Chronic Dis*. 2020;11:2040622320970354.

[4] Daliu P, Santini A, Novellino E. From pharmaceuticals to nutraceuticals: bridging disease prevention and management. *Expert Rev Clin Pharmacol*. 2019;12(1):1–7.

[5] AlAli M, Alqubaisy M, Aljaafari MN, AlAli AO, Baqais L, Molouki A, et al. Nutraceuticals: transformation of conventional foods into health promoters and disease preventers. *Molecules*. 2021;26(9):2540.

[6] Lourenço SC, Moldão-Martins M, Alves VD. Antioxidants of natural plant origins: from sources to food industry applications. *Molecules*. 2019; 24(22): 4132.

[7] Siddeeg A, AlKehayez NM, Abu-Hiamed HA, Al-Sanea EA, Al-Farga AM. Mode of action and determination of antioxidant activity in dietary sources. *Saudi J Biol Sci*. 2021; 28(3): 1633-44.

[8] Flieger J, Flieger W, Baj J, Maciejewski R. Antioxidants: classification, natural sources, activity measurements, and applications. *Materials*. 2021; 14(15): 4135.

[9] Di Cesare M, Perel P, Taylor S, Kabudula C, Bixby H, Gaziano TA, et al. The heart of the world. *Glob Heart*. 2024;19(1).

[10] Ojeda-Granados C, Campisi E, Barchitta M, Agodi A. Genetic, lifestyle and metabolic factors contributing to cardiovascular disease. *Front Nutr*. 2024;11:1379785.

[11] Krupa KN, Fritz K, Parmar M. Omega-3 fatty acids. In: *StatPearls* [Internet]. Treasure Island (FL): StatPearls Publishing; 2025.

[12] Zahra M, Abrahamse H, George BP. Flavonoids: antioxidant powerhouses and their role in nanomedicine. *Antioxidants*. 2024;13(8):922.

[13] Hollman PC, Cassidy A, Comte B, Heinonen M, Richelle M, Richling E, et al. Biological relevance of direct antioxidant effects of polyphenols. *J Nutr*. 2011;141(5):989S-1009S.

[14] Tufail M, Hu JJ, Liang J, He CY, Wan WD, Huang YQ, et al. Hallmarks of cancer resistance. *iScience*. 2024;27(6).

[15] Zafar A, Khatoon S, Khan MJ, Abu J, Naeem A. Advancements and limitations in traditional anti-cancer therapies. *Discover Oncol*. 2025;16(1):607.

[16] Sapra A, Bhandari P, Wilhite Hughes A. Diabetes (nursing).

[17] Agrawal P, Singh BR, Gajbe U, Kalambe MA, Bankar M. Managing diabetes mellitus with millets. *Cureus*. 2023;15(9).

[18] Sahu P, Mishra S. Ayurveda management of PCOS by single herbs and combinations. *J Ayurveda Integr Med Sci*. 2023;8(12):246-50.

[19] De LC. Edible seeds and nuts in human diet for immunity development. *Int J Recent Sci Res*. 2020;6(11):38877-81.

[20] Mueed A, Shibli S, Korma SA, Madjirebaye P, Esatbeyoglu T, Deng Z. Flaxseed bioactive compounds. *Foods*. 2022;11(20):3307.

[21] Batool M, Ranjha MM, Roobab U, Manzoor MF, Farooq U, Nadeem HR, et al. Nutritional value and therapeutic benefits of pumpkin. *Plants*. 2022;11(11):1394.

[22] Tian GL, Miao H, Zhang SP, Wang Y, Gu XF. Chemical components and efficiency of cucumber seeds.

[23] Hassan SA, Khalid S, Javaid H, Zafar S, Abdi G, Aadil RM. Muskmelon seeds as sustainable food ingredients. *Food Chem Adv*. 2025;7:101008.

[24] Nissar J, Sidiqi US, Dar AH, Akbar U. Nutritional composition of watermelon seeds. *Sustain Food Technol*. 2025;3(2):375-95.
[25] Chemical composition and antimicrobial activity of essential oils of *Coriandrum sativum*. *Food Sci Nutr*. 2024;12(6):3872-82.
[26] Taheri SE, Bazargan M, Vosough PR, Sadeghian A. Peanut: chemical structure, oxidation, and storage. *J Food Compos Anal*. 2024;125:105770.
[27] Uma D, Jayamani P, Rubila S, Raguna J. Nutraceutical profile of red gram genotypes. *Madras Agric J*. 2025;112(1):21-8.
[28] Basha SA, Rao UP. Bioactivities of green gram milling by-products. *Food Biosci*. 2017;19:134-41.
[29] Arockianathan PM, Rajalakshmi K, Nagappan P. Composition and antioxidant activity of *Vigna mungo* seed coat. *Bioinformation*. 2019;15(8):579.
[30] Xiao S, Li Z, Zhou K, Fu Y. Chemical composition of chickpea cultivars. *Food Sci Nutr*. 2023;11(1):236-48.
[31] Patangare SS, Pawar VS, Shinde ST. Nutritional composition of horse gram. *Int J Chem Stud*. 2019;7(2):53-5.
[32] Xu S, Qin L, Mazhar M, Zhu Y. Functional components and glycemic index of kidney beans. *Front Nutr*. 2022; 9: 1044427.
[33] Semwal P, Gupta S, Joshi G, Wahajuddin M, Kumar B. Chemical constituents of Indian pulses. *Legume Sci*. 2025;7(4):e70055.
[34] Mohammed FS, Sevindik M, Uysal İ, Çesko C, Koraqi H. Chemical composition of cumin. *Measurement Food*. 2024;14:100157.
[35] Alam P, Abdel-Kader MS, Alqarni MH, Zaatout HH, Ahamad SR, Shakeel F. Chemical composition of fennel seed extract. *J Food Sci Technol*. 2019;56(5):2395-403.
[36] Singh H, Meghwal M. Ajwain as a potential phytochemical source. *Pharma Innov J*. 2019;8:599-603.
[37] Yasothai R. Chemical composition of fenugreek seed. *Pharma Innov J*. 2021;10(7):944-7.
[38] Ghosh K, Bhattacharya TK. Chemical constituents of *Piper betle* roots. *Molecules*. 2005;10(7):798-802.
[39] Paikra BK, Gidwani B. Phytochemistry and pharmacology of *Moringa oleifera*. *J Pharmacopuncture*. 2017; 20(3):194.
[40] Rajendran MP, Pallaiyan BB, Selvaraj N. Essential oil of *Murraya koenigii* leaves. *Avicenna J Phytomed*. 2014;4(3):200.
[41] Brahmi F, Khodir M, Mohamed C, Pierre D. Chemical composition of *Mentha* species. In: *Aromatic and Medicinal Plants*. IntechOpen; 2017.
[42] Kumar S, Ahmad R, Saeed S, Azeem M, Mozūraitis R, Borg-Karlson AK, et al. Chemical composition of coriander cultivars. *Front Plant Sci*. 2022;13:820644.
[43] Pasricha V, Gupta RK. Nutraceutical potential of methi and kasuri methi. *J Pharmacogn Phytochem*. 2014;3(4).
[44] Kumar M, Tomar M, Amarowicz R, Saurabh V, Nair MS, Maheshwari C, et al. Guava leaves: nutritional and phytochemical profile. *Foods*. 2021;10(4):752.
[45] Abdelrahman GH, Mariod AA. *Tamarindus indica*: phytochemical constituents and medicinal uses. In: *Wild Fruits*. Springer; 2019. p.229-38.
[46] Hassan SM, Mughal SS, Aslam AS, Mushtaq MA, Munir MU, Pervez SU, et al. *Emblica officinalis* (Amla): a review. *Biomed Nurs*. 2020;6:22-30.
[47] Deo YK, Reddy KR. Pharmacological properties of Brahmi. *Int J Ayurvedic Med*. 2013;4(2):92-9.
[48] Chahal KK, Dhaiwal K, Kumar A, Kataria D, Singla N. *Trachyspermum ammi*: chemical composition and biological properties. *J Pharmacogn Phytochem*. 2017;6(3):131-40.
[49] Gupta S, Nag S, Paul R, Mondal S. *Tinospora cordifolia*: an optimistic herb. *Pharmacogn Res*. 2024;16(2).
[50] Bergman M, Varshavsky L, Gottlieb HE, Grossman S. Antioxidant activity of aqueous spinach extract. *Phytochemistry*. 2001;58(1):143-52.
[51] Nur MA, Islam M, Biswas S, Hasan MN, Rahman MM, Uddin MJ, et al. Biological activities of *Basella alba*. *Heliyon*. 2023;9(11).
[52] Riaz G, Naik SN, Garg M, Chopra R. Phytochemical composition of *Hibiscus sabdariffa*. *Lett Appl NanoBioSci*. 2021; 10(2): 2138-47.
[53] Walter TM, Merish S, Tamizhamuthu M. Review of *Alternanthera sessilis*. *Int J Pharmacogn Phytochem Res*. 2014;6(2):249-54.
[54] Ambule VS, Mendhekar VK, Banarase VM. Review on Chukra (*Rumex vesicarius* Linn.).
[55] Ravichandran G, Lakshmanan DK, Murugesan S, Elangovan A, Rajasekaran NS, Thilagar S. Polyphenolics of dragon fruit. *Food Res Int*. 2021; 140: 110081.
[56] Bartkiene E, Starkute V, Jomantaite I, Zokaityte E, Mockus E, Tolpeznikaite E, et al. Multifunctional nutraceutical composition. *Foods*. 2023; 12(8): 1690.
[57] Maurya S, Sharma N, Tiwari M, Singh A, Singh S, Yadav K. A review article on nutraceuticals. *Int Res J Modernization Eng Technol Sci*. 2022.

Source of Support: Nil. Conflicts of Interest: None declared.